# A Review of the Food Habits of the Insect Fauna Inhabiting Cattle Droppings in North Central California[1]

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A two-year study (1971–73) in the Sierra Nevada foothills of California consisted of: 1) a quantitative analysis of the differences in diversity and abundance of the insect fauna colonizing and inhabiting undisturbed cattle droppings in four different pasture and rangeland ecosystems; and 2) a study of the relationship between the diversity and abundance of insect inhabitants per cowpat and the rate of pat degradation (Merritt 1974, Merritt and Anderson, in prep.). During this time observations were made on the feeding habits of selected dung insects and a general literature survey was conducted. This report reviews the known food habits of the insects recorded in the previous study. Many of the families, genera and species considered here, also occur in bovine manure throughout North America and other parts of the world. Table 1 is a general tabulation of the food habits of dung-associated insects for both adult and immature stages.

Several studies have been conducted on the biology, ecology and succession of insects inhabiting cattle droppings (Hafez 1939, Mohr 1943, Snowball 1944, Laurence 1954, Poorbaugh 1966, Sanders and Dobson 1966); however, few have dealt specifically with the food habits, or food webs of insect communities inhabiting bovine manure. Hammer (1941) studied the life histories of various species, based on field observations, and stressed their biology, food and reproduction. Valiela (1974) studied qualitative and quantitative changes in species composition and in the structure of food webs during the succession of insects in cattle droppings. He grouped species into trophic "guilds" or groups of species which fed on similar food and had similar feeding behavior. He found that neither food nor predators appeared to limit populations of dung feeders, and that local alterations in the environment and in the dung may set limits on the numbers of predators and prey. Merritt (1974) showed that loco- and microclimatological factors[3]

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[3] Lococlimate refers to the conditions prevailing in the environment close to the dung and microclimate refers to the condition prevailing in the actual dung pile.

were most important in determining the diversity and abundance of insects colonizing dung, except during late spring when adults of *Aphodius fimetarius* (L.) (Coleoptera: Scarabaeidae) invaded and disrupted the droppings, thereby reducing the developmental sites of certain dipteran larvae.

## COLEOPTERA

*Hydrophilidae.*—According to Sanders and Dobson (1966), and Hafez (1939), adults and larvae of *Cercyon* spp. feed on dung; however, literature on the ecology, life history, and taxonomy of this group is scarce (McDaniel et al. 1971). I checked numerous specimens of this group for parasitic nematodes and found that the gut contents often consisted of a brownish-black material which I assumed was dung. Therefore, I agree with the above authors that the adults are dung feeders (Table 1). Feeding habits of the larvae were not observed. Larvae of *Sphaeridium* spp. were observed feeding on various Diptera and Coleoptera immatures by Mohr (1943), Poorbaugh (1966), and Bourne and Hays (1968). Hammer (1941) stated that the adults of *Spaeridium scarabaeoides* L. were carnivorous and fed on egg heaps of Diptera; however, more recent studies (Sanders and Dobson 1966, Thomas 1967, Kessler and Balsbaugh 1972, Macqueen 1973, Merritt, pers. obs.) indicated that adults were generally scavengers (Table 1). Adults of *Sphaeridium* spp. played an important role in the ecological succession of animal life in the dung. They were often observed burrowing in and out of the dung shortly after pats were dropped, thus providing aeration to the pat and permitting staphlinids and parasitic Hymenoptera to use their tunnels to locate prey (Gary and Wingo 1971, Merritt 1974). Valiela (1969) showed that face fly mortality in the dung was greater in the presence of *Sphaeridium* (a burrower) and a predator rather than a predator alone. Several authors (Mohr 1943, Sanders and Dobson 1966, McDaniel et al. 1971) have discussed the ecological importance of the tunneling activities of *Sphaeridium.*

*Scarabaeidae.*—Adults and larvae of aphodines feed on dung and digest only dissolved albuminous substances (Madle 1934, Landin 1961) (Table 1). The larvae also digest bacterial albumens which may account for their subsistence in old dung heaps (Landin 1961).

*Staphylinidae.*—Little work has been conducted on the food habits of dung-inhabiting *Staphylinidae* in the United States (I. Moore, Univ. Calif., Riverside, pers. comm.) (Table 1). Life history studies have been conducted on a few species, such as on *Aleochara tristis* Gravenhorst (Drea 1966) and on *Aleochara bimaculata* Gravenhorst (Wingo

TABLE 1. Food habits of dung associated insects in north central California.

| TAXA | Adult | | | | Immature | | | | Reported Prey | A Reference Citation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dung | Pred[a] | Par[b] | Other[c] | Dung | Pred | Par | Other | | |
| COLEOPTERA | | | | | | | | | | |
| Histeridae | | | | | | | | | | |
| *Peranus bimaculatus* L. | - | X | - | - | - | X | X | - | Diptera & Coleoptera larvae | Hafez (1939) |
| *Saprinus* sp. | - | X | - | - | - | X | - | - | Diptera & Coleoptera larvae | Hafez (1939) |
| Hydrophilidae | | | | | | | | | | |
| *Cercyon* spp. (2)[d] | X | - | - | - | X?[e] | - | - | - | _____ | Sanders & Dobson (1966) |
| *Sphaeridium* spp. (3) | X | - | - | - | - | X | - | - | Diptera & Coleoptera larvae | Thomas (1967) - Adults<br>Mohr (1943)-Larvae |
| Rhizophagidae | | | | | | | | | | |
| *Monotoma picipes* (Herbst.) | - | - | - | X | - | - | - | X? | _____ | Hafez (1939) |
| Scarabaeidae | | | | | | | | | | |
| *Aphodius* spp. (6) | X | - | - | - | X | - | - | - | _____ | Landin (1961) |
| Staphylinidae | | | | | | | | | | |
| *Aleochara* spp. (2+) | X | X | - | - | - | - | X | - | Diptera eggs, larvae, pupae | Drea (1966) |
| *Aleochara bimaculata* Gray | - | X | - | - | - | - | X | - | Diptera eggs, larvae, pupae | Wingo et al. (1967, 1974) |
| *Aleochara bipustulata* L. | - | X | - | - | - | - | X | - | Diptera eggs, larvae, pupae | Thomas & Morgan (1972a) |
| Aleocharinae (5+) | - | X? | - | - | - | - | - | - | Unknown | I. Moore (Pers. Comm.) |
| *Aploderus annectans* LeC | - | X? | - | - | - | - | - | - | Unknown | I. Moore (Pers. Comm.) |
| *Hyponygrus* sp. | X | X | - | - | - | - | - | - | Diptera larvae & Coleoptera adults | Valiela (1969) |
| *Leptacinus* spp. (2) | - | X? | - | - | - | - | - | - | Diptera larvae | Snowball (1944) |
| *Lithocharis ochracea* Grav. | - | X? | - | - | - | - | - | - | Unknown | I. Moore (Pers. Comm.) |
| *Oxytelus* sp. | X | X? | - | - | - | - | - | - | Unknown | Valiela (1974) |
| *Philonthus* spp. (4) | X | X | - | - | - | X | - | - | Diptera eggs, larvae | Valiela (1969) |
| *Platystethus americanus* Erich. | X | X | - | - | - | - | - | - | Diptera larvae | Mohr (1943) |
| *Quedius* sp. | - | X? | - | - | - | - | - | - | Unknown | I. Moore (Pers. Comm.) |
| DIPTERA | | | | | | | | | | |
| Anthomyiidae | | | | | | | | | | |
| *Calythea micropterx*(Thom.) | - | - | - | X | X | - | - | X? | _____ | Merritt (1974) |
| *Hylemya* spp. (2) | X | - | - | X | X | - | - | - | _____ | Mohr (1943) |
| *Scatophaga stercoraria* (L.) | - | X | - | X | X | - | - | - | Diptera adults | Foster (1970) |
| *S. furcata* (Say) | - | X | - | X | X | - | - | - | Diptera adults | Mohr (1943) |

TABLE 1. (Cont.)

| TAXA | Adult | | | | Immature | | | | Reported Prey | A Reference Citation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dung | Pred[a] | Par[b] | Other[c] | Dung | Pred | Par | Other | | |
| Cecidomyiidae | | | | | | | | | | |
| *Colpodia* sp. | - | - | - | X | X? | - | - | X | _____ | Cole (1969) |
| *Tetraxyphus* sp. | - | - | - | X | X? | - | - | X | _____ | Cole (1969) |
| Ceratopogonidae | | | | | | | | | | |
| *Forcipomyia* spp. (2) | - | - | - | X | X? | - | - | X | _____ | Saunders (1924) |
| Chironomidae | | | | | | | | | | |
| *Smittia* sp. | - | - | - | X | X? | - | - | X | _____ | Strenzke (1950) |
| Drosophilidae (1) | - | - | - | X | X? | - | - | X | _____ | Baumberger (1919) |
| Emipididae | | | | | | | | | | |
| *Drapetis* sp. | - | X | - | - | - | X | - | - | Coleoptera adults | Laurence (1952)-Adults<br>Papp (1971)-Larvae |
| Muscidae | | | | | | | | | | |
| *Pseudophaonia orichalcoides* Huckett | - | - | - | X | X? | - | - | - | | Merritt (1974) |
| *Haematobia irritans* L. | - | - | X | X | X | - | - | - | Vertebrate host(cattle) | Hammer (1941) |
| *Hydrotaea* spp. (2) | X | - | - | X | - | X | - | - | Diptera larvae | Hammer (1941) - Adults<br>Porchinskii (1911)-Larvae |
| *Morellia micans* (Mac.) | X | - | - | X | X | - | - | - | _____ | Hammer (1941) |
| *Musca autumnalis* (DeG.) | X | - | - | X | X | - | - | - | _____ | Hammer (1941) |
| *Myospila meditabunda* (F.) | X | - | - | X | - | X | - | - | Diptera larvae | Hammer (1941) - Adults<br>Poorbaugh (1966) - Larvae |
| *Orthellia caesarion* (M.) | X | - | - | X | X | - | - | - | _____ | Hammer (1941) |
| Psychodidae<br>*Psychoda* spp. (3) | X | - | - | X | X | - | - | - | _____ | Laurence (1953) |
| Sarcophagidae<br>*Ravinia* spp. (3) | X | - | - | X | X | - | - | - | _____ | Mohr (1943) |
| Scatopsidae (1) | - | - | - | X | X | - | - | X | _____ | Baumberger (1919) |
| Sciaridae (2) | - | - | - | X | X | - | - | X | _____ | Snowball (1944) |
| Sepsidae (8) | X | - | - | X | X | - | - | - | _____ | Hammer (1941) |
| Sphaeroceridae (9) | X | - | - | X | X | - | - | - | _____ | Hammer (1941) |
| Stratiomyiidae (3) | - | - | - | X | X | - | - | - | _____ | Hammer (1941) |

TABLE 1. (Cont.)

| TAXA | Adult | | | | Immature | | | | Reported Prey | A Reference Citation |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dung | Pred[a] | Par[b] | Other[c] | Dung | Pred | Par | Other | | |
| Tipulidae (1) | - | - | - | X | X? | - | - | X | _____ | Baumberger (1919) |
| HYMENOPTERA | | | | | | | | | | |
| Bethylidae (1) | - | - | - | X | - | - | X | - | Unknown | Blume (1970) |
| Brăconidae | | | | | | | | | | |
| Aphaereta pallipes (Say) | - | - | - | X | - | - | X | - | Diptera pupae | Garry and Wingo (1971) |
| Asobara sp. | - | - | - | X | - | - | X | - | Diptera pupae | Mohr (1943) |
| Idiasta sp. | - | - | - | X | - | - | X | - | Diptera pupae | Mohr (1943) |
| Pentapleura sp. | - | - | - | X | - | - | X | - | Diptera pupae | Merritt (1974) |
| Phenocarpa sp. | - | - | - | X | - | - | X | - | Diptera pupae | Turner et al. (1968) |
| Cynipidae | | | | | | | | | | |
| Eucolia rufocincta (K) | - | - | - | X | - | - | X | - | Diptera Pupae | Thomas and Wingo (1968) |
| Kleidotoma fossa K | - | - | - | X | - | - | X | - | Diptera pupae | Mohr (1943) |
| Diapriidae | | | | | | | | | | |
| Phaenopria sp. | - | - | - | X | - | - | X | - | Diptera pupae | Mohr (1943) |
| Figitidae | | | | | | | | | | |
| Figites sp. | - | - | - | X | - | - | X | - | Diptera pupae | Mohr (1943) |
| Xyalophora sp. | - | - | - | X | - | - | X | - | Diptera pupae | Kessler & Balsbaugh (1972) |
| Ichneumonidae | | | | | | | | | | |
| Phygadeuon sp. | - | - | - | X | - | - | X | - | Diptera pupae | Combs & Hoelscher (1969) |

[a] Predators

[b] Parasitoids

[c] Either phytophagous (e.g., nectar), saprophagous (e.g., fungi, bacteria), or unknown.

[d] The number of species representative for that particular taxon given. Due to the lack of information on the food habits of specific species and the general nature of this table, each species has not been listed separately. A complete list of species is given by Merritt (1974).

[e] ?-presumed to feed, but not certain.

et al. 1967). In each of these species the newly hatched larva entered a fly puparium, developed within a parasite of the pupa, and emerged as an adult bettle. The adult beetles were predacious on eggs and larvae of muscoid Diptera (Wingo et al. 1967, Drea 1966). Host records of parasitic staphylinids belonging to the genus *Aleochara* in America were reviewed by Moore and Legner (1971). Members of the genus *Philonthus* are predacious as adults and larvae on Diptera eggs and immatures (Sanders and Dobson 1966, Macqueen 1973). *Philonthus cruentatus* (Gmelin) was shown to be one of the most effective predators on immature stages of the face fly, *Musca autumnalis* (DeGeer) (Valiela 1969, Wingo et al. 1974) and horn fly, *Haematobia irritans* (L.) (Thomas and Morgan 1972b).

### DIPTERA

Hammer's (1941) work is the most complete study dealing with the food habits of flies inhabiting cattle droppings. Information is lacking on the adult habits of many species and more evidence is needed regarding the larval habits inside the dung (Table 1). Faunal studies included lists of dipteran species "reared" from dung; however, this does not necessarily imply that the specific species feeds entirely on the dung itself (Valiela 1974, in part). The larvae may feed on microorganisms (e.g. fungi, bacteria) growing on the dung (Baumberger 1919) or they may be facultative carnivores, requiring live prey for normal development (Muirhead Thompson 1937, Hammer 1941). For example, several species of nematoceran Diptera have been reared from cattle droppings (Hafez 1939, Mohr 1943, Poorbaugh 1966); however, gut content analysis has shown that some members of this group feed on decomposing vegetable matter (e.g., fungal spores and hyphae) (Saunders 1924, Strenzke 1950) (Table 1).

Only two genera of Diptera were reported predacious as adults, *Scatophaga* spp. (Anthomyiidae) (Hammer 1941, Foster 1970) and *Drapetis* spp. (Empididae) (Laurence 1952) (Table 1). In northern California, Foster (1970) found that *Scatophaga stercoraria* fed on dung flies in the field, primarily of the families Anthomyiidae and Sphaeroceridae. Laurence (1952) recorded an adult *Drapetis* sp. feeding on a small staphylinid. The larvae of *Drapetis* are presumed predators but little is known about their habits (Rogers 1973, Papp 1971). Other predacious larvae found in cattle droppings in north central California were members of the genus *Hydrotaea*, and *Myospila meditabunda* (F.) (Muscidae); however, they were found in relatively low numbers (Merritt 1974). In contrast, Poorbaugh (1966) found

that the larvae of *M. meditabunda* caused heavy mortality to coprophagous fly populations in coastal California. Hammer (1941) reported that *Hydrotaea* larvae could not live on a diet of dung alone but required living fly larvae for development. He considered the adults of *Hydrotaea* and those of another muscid, *Morellia*, as facultative bloodsuckers, since they procure blood and secretions from wounds on cattle. The majority of adult Diptera feed mainly on the liquids of dung and often frequent flowers where they suck nectar (Hammer 1941) (Table 1).

## HYMENOPTERA

The Hymenoptera consisted largely of pupal parasitoids of Diptera (Table 1). The search for biological methods of control against pestiferous flies has led to much current research on the biology and population dynamics of parasitic Hymenoptera and their associated hosts. Theoretical and applied studies on the bio-ecology of natural enemies are reviewed by Legner and Poorbaugh (1972). Further descriptions of host-parasite associations can be found in Greenberg (1971). Merritt (1974) found a braconid, *Pentapleura* sp. (*P. triticaphis* (Fitch) or *P. foreolata* Viereck) parasitizing *Scatophaga stercoraria* and *S. furcata* during the spring in the Sierra Nevada foothills.

## DISCUSSION

In reviewing Table 1, two general observations can be made. First, except for the empid *Drapetis*, no Diptera were reported predacious on Coleoptera, while approximately 50 percent of the Coleoptera and all the Hymenoptera have been cited as predators or parasitoids of Diptera. Also, in contrast to northern Europe where Hammer (1941) found several species of predacious Diptera larvae inhabiting cattle droppings, only a few species were recorded from droppings in California (Table 1). Anderson and Poorbaugh (1968) implied a relationship between fewer numbers of horn flies and face flies in Europe with higher levels of predacious fly larvae, as compared to the situation in the United States where there are fewer species of predacious larvae and higher populations of pestiferous flies. Although Blume et al. (1970) showed ". . . a significant negative correlation ($r = 0.898$) between the mean numbers of horn flies and the mean numbers of insects of other species produced per dropping . . . ," the exact nature of this relationship needs further quantitative investigation. In Australia the pest fly situation represented an extreme example where introduced pestiferous flies breeding in cattle dung experienced little competition for food or losses

due to predation from other arthropods (Bornemissza 1960, 1970). They have undertaken a major research program there to evaluate the introduction of exotic dung beetles to reduce the numbers of pest flies breeding in cattle droppings (Waterhouse 1974).

The second general observation is that there are limited data regarding the food habits of insect species inhabiting cattle droppings (Table 1). In the United States, life history studies on many groups inhabiting dung, such as the Aleocharinae and other staphylinid subfamilies, have not been conducted (I. Moore, Univ. Calif., Riverside, pers. comm.). This is largely due to the difficulties involved in examining the interspecific and intraspecific interactions inside the dung. Clarifying the several insect trophic levels within the cow dung community will require more detailed investigations.

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## RECENT LITERATURE

THE NORTH AMERICAN SPECIES OF HETEROSARUS ROBERTSON (HYMENOPTERA: APOIDEA). P. H. Timberlake. University of California Publications in Entomology, 77:1–56. 1975.

In this review of the panurgine bee genus *Heterosarus*, 55 species are treated, 37 being described as new. Male genital armature and subgenital plate are figured for all species available.